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EFFECT OF POWERED PROPELLERS ON THE AERODYNAMIC CHARACTERISTICS AND THE PORPOISING STABILITY OF A DYNAMIC MODEL OF A LONG-RANGE FLYING BOAT

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INTRODUCTION

The tests described in this report were made on a 1/8-full-size model of a large, long-range, twin-engine flying boat in NACA tank no. 1. The airplane had a wing loading of 43.9 pounds per square foot and a power loading of 11.5 pounds per horsepower. Its arrangement was such that 34.2 percent of the wing area and 56.1 percent of the horizontal tail area were included within the fore-and-aft projection of the propeller disks.

The model was fitted with leading-edge slats to make the angle of attack for maximum lift coefficient correspond with that of the airplane at the low Reynolds number associated with the tank tests (3.28×10^6 based on the mean aerodynamic chord and the get-away speed of the model). The model was equipped with two three-blade metal propellers of scale diameter and form, power for which was furnished by two variable-frequency alternating-current motors. Sufficient power was available to develop scale thrust with the propellers.

The tests were divided into two parts: (1) aerodynamic tests to determine the effect of the slipstream and thrust from the powered propellers on the lift and trimming-moment characteristics, and (2) hydrodynamic tests to determine the effect of the powered propellers on the range of stable locations of the center of gravity.

AERODYNAMIC TESTS

Aerodynamic tests were made by suspending the model above the water with the trim axis at a height that allowed

a small clearance of the stern post at a trim of 16°. The trim axis was located at the point corresponding to the position of the center of gravity at 25-percent mean aerodynamic chord and the trimming-moment coefficients were measured about this axis. All aerodynamic data were obtained at a constant speed of 45 feet per second.

In tank tests of powered models, the effects of power are assumed to be approximately simulated by dimensionally scaled propellers turning at a speed that will cause the propellers to develop scale thrust. In the case of the present model, the values of thrust assumed and the corresponding propeller speed, as determined from a calibration of the model propellers in a wind tunnel, were as follows:

	Propeller speed (rpm)
Zero thrust	0
One-half of scale thrust at $V = 35$ fps (model) . .	4200
Full static thrust	4700
Full thrust at $V = 60$ fps (model)	5300

The curves of aerodynamic lift coefficient against trim and trimming-moment coefficient given in figure 1 show that the change from zero thrust to one-half of scale thrust has a relatively greater effect on the aerodynamic characteristics than the change from one-half of scale thrust to full thrust. Also, the curves show that the differences between the characteristics with propellers turning at 4700 rpm and at 5300 rpm are negligible. The last-mentioned conclusion is significant in that continuous adjustment of the propeller speed of the model during an accelerated run appears unnecessary for simulating the variation of thrust with speed of the full-size propellers.

HYDRODYNAMIC TESTS

Details of the test procedure used to determine the range of stable locations of the center of gravity may be found in reference 1.

Figure 2 shows the large difference in the stable range between half-thrust and full-thrust conditions. For the hydrodynamic tests, full thrust was represented by a propeller speed of 5000 rpm. The principal effect of in-

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creasing the thrust from half (4200 rpm) to full (5000 rpm) is to shift both the forward and the after limits of stability aft. The after limit is moved aft to a much lesser degree that the forward limit.

Three effects of power are involved in the location of the stable range of the center of gravity. First, the slipstream over the wing causes an increase in the lift and a decrease in the load on the water. The trim limits of stability are thus raised to higher trims. (See reference 1.) Second, the thrust produces a nose-down moment; this effect is probably the most important in determining the range of stable locations of the center of gravity. Third, the slipstream on the tail changes the moment produced by the tail and increases the effectiveness of the elevator.

CONCLUSIONS

1. When the hydrodynamic stability of a flying boat is determined by means of tests of a dynamic model, the scale thrust should, if possible, be developed by means of operating propellers of at least approximately scale diameter. On a model of a long-range flying boat of conventional design, large increases in wing lift and tail moment may be expected to follow the use of powered propellers. In addition, the thrust moment considerably changes the trims assumed by the flying boat. These effects greatly influence the width of the range of stable locations of the center of gravity.

2. With the present methods of determining the stability of dynamic models, exact simulation of full-size variation of thrust with speed is unnecessary.

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REFERENCE

1. Olson, Roland E., and Land, Norman S.: The Longitudinal Stability of Flying Boats as Determined by Tests of Models in the NACA Tank. I - Methods Used for the Investigation of Longitudinal-Stability Characteristics. NACA A.R.R., Nov. 1942.

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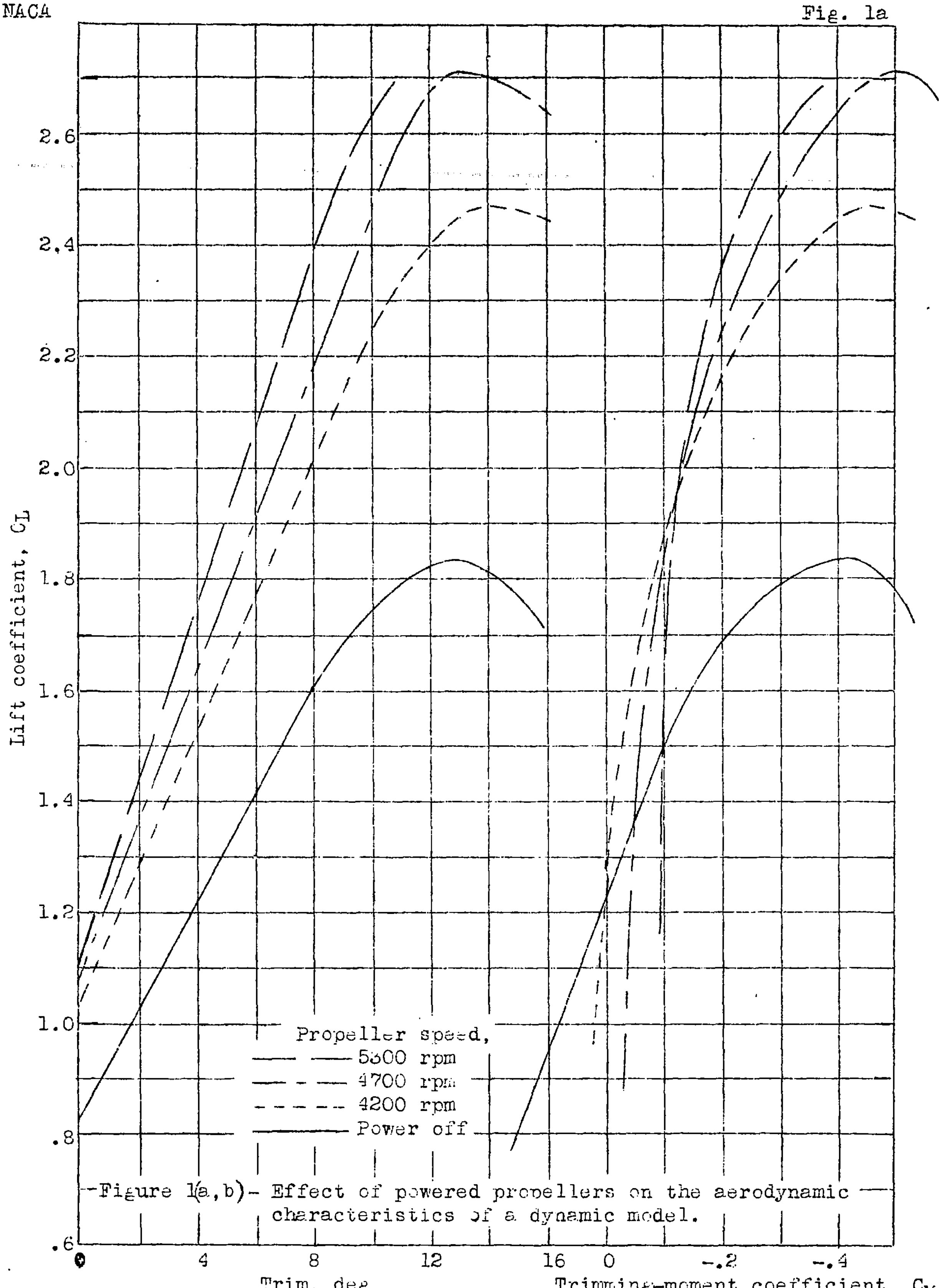

Figure 1(a,b) - Effect of powered propellers on the aerodynamic characteristics of a dynamic model.

(a) Elevators neutral

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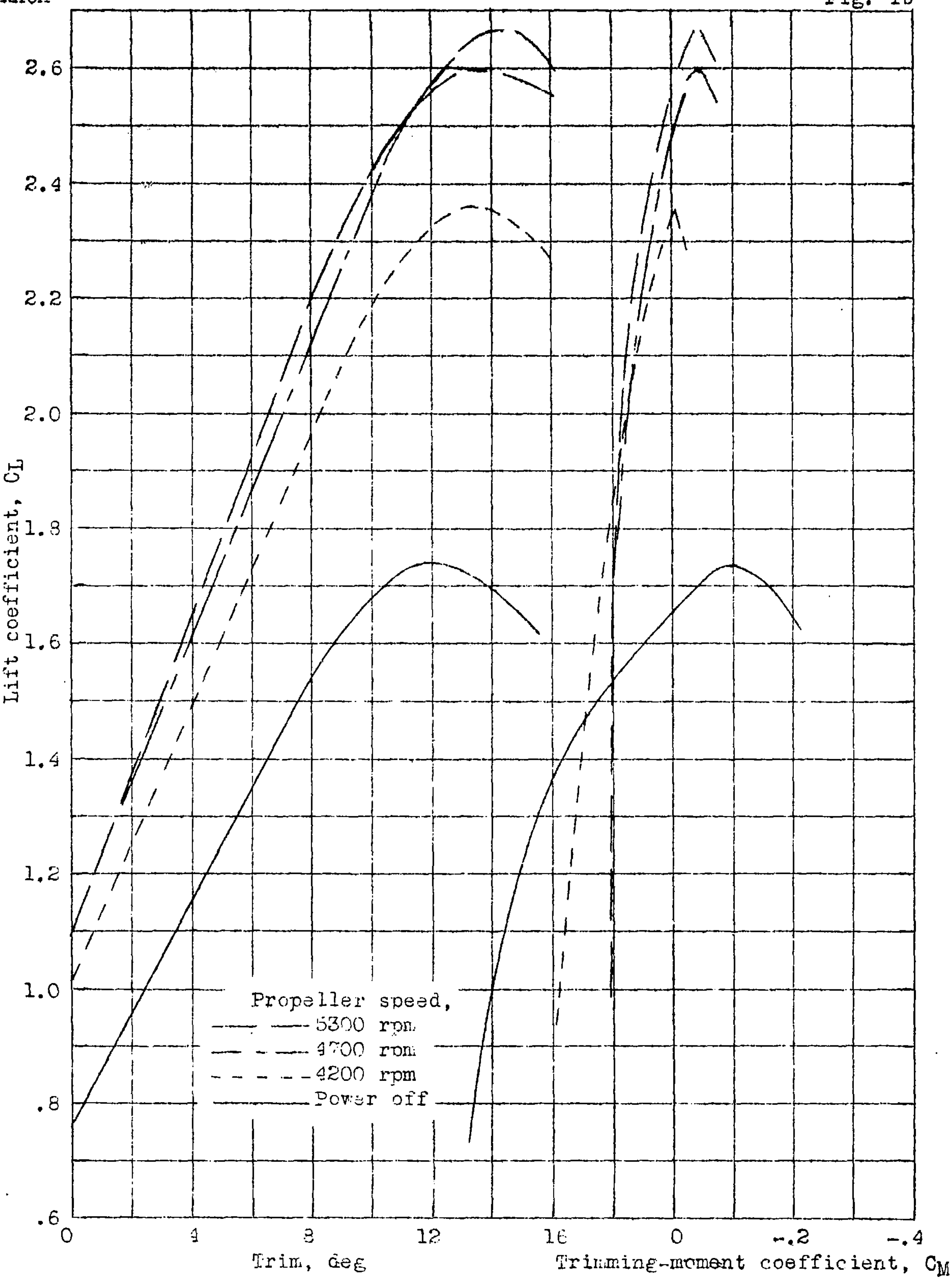

(b) Elevators 25° up

Figure 1.-(Concluded)

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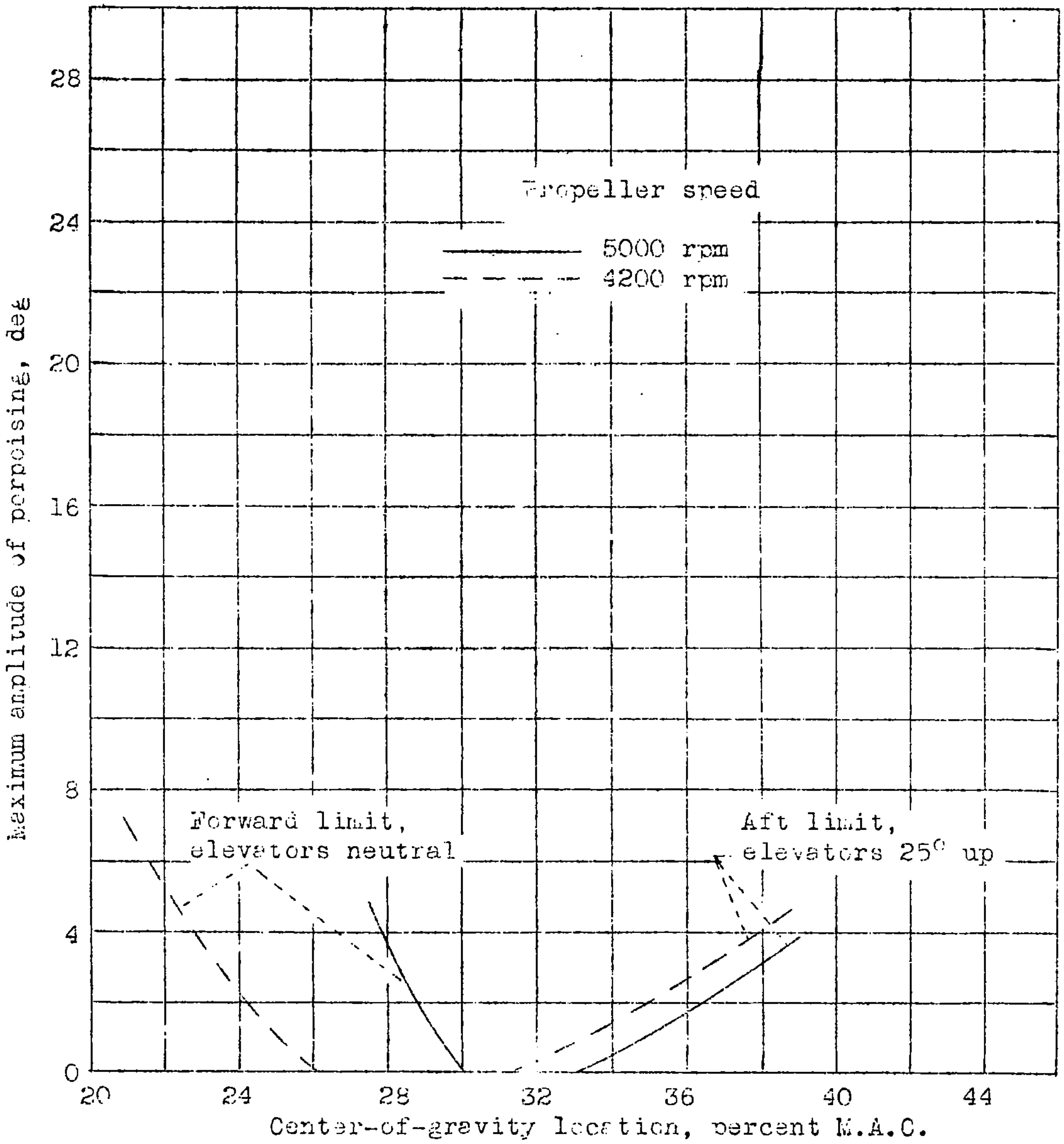

Figure 2.- Effect of powered propellers on the limits of stable locations of the center of gravity of a dynamic model.